

# **Sixth Annual Conference on Carbon Capture & Sequestration**

*Terrestrial-Related Sequestration R&D*

## **A National Carbon Atlas and Geospatial Inventory of CO<sub>2</sub> Sources and Sinks**

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May 7-10, 2007 • Sheraton Station Square • Pittsburgh, Pennsylvania

# Regional Partnerships





**Pittsburgh, circa 1910**



**Donora, PA noon, 10/29/1948**

**20 DIED. THE GOVERNMENT TOOK HEED.  
IN 1948, A KILLER FOG SPURRED AIR CLEANUP**

Philadelphia Inquirer

[www.pitt.edu/~mrosenme/north\\_america.htm](http://www.pitt.edu/~mrosenme/north_america.htm)



**On Friday 5 December 1952 a dense smoke-filled fog shrouded London and it hung over the city for the next four days. London came to a standstill. Over 4,000 people died, motor vehicles were abandoned, trains were disrupted and airports were forced to close.**

[http://news.bbc.co.uk/2/hi/uk\\_news/england/2546563.stm](http://news.bbc.co.uk/2/hi/uk_news/england/2546563.stm)



Carnegie Museum of Art  
Claude Monet's "Waterloo Bridge, London" (1903).  
<http://www.cmoa.org>





## Riggs Glacier in Muir Inlet of Alaska's Glacier Bay National Park

1941

2004

<http://sfgate.com/cgi-bin/article.cgi?f=/c/a/2004/12/17/MNGARADH401.DTL>



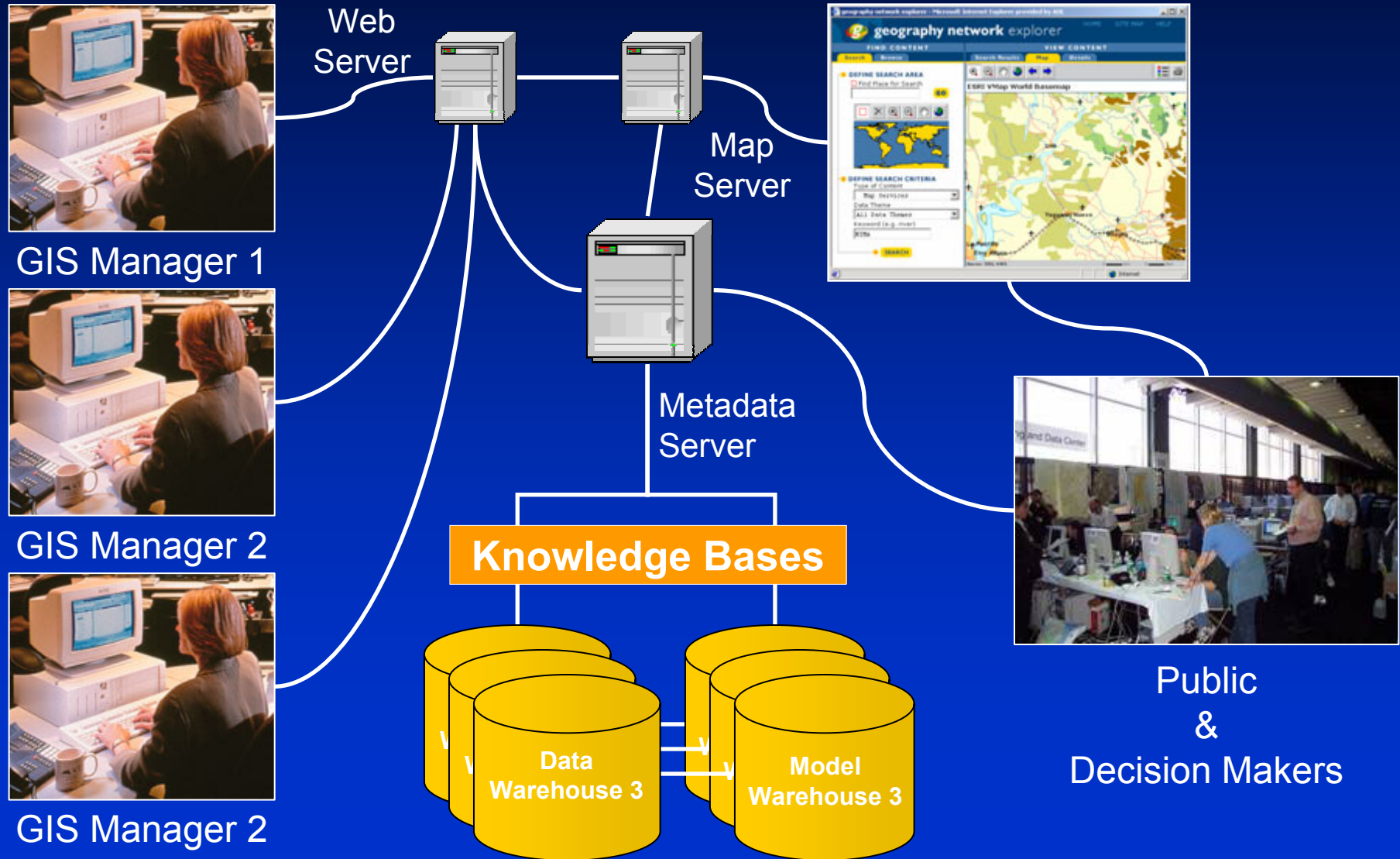
# NatCarb Over-Arching Goals



- Connection
  - Bring Society Together with Possible Solutions
  - Complete Online Access to Information & Tools
    - » Expert, Decision Maker, General Public
- Complexity
  - Harder to Display
  - Harder to Analyze (Integrate Data with Models)
  - Harder to Manage
- Coordination
  - Bring the Players Together
  - Bring the Data Together

**Provide Basis for Better Policies and Decisions**

# Distributed GIS as Glue



# NatCarb a Geoportal Linking Partnerships

## *Characterize National Potential for Broad-Scale Carbon Sequestration*

### Role of Distributed GIS:

- National Carbon Atlas of Carbon Sources and Potential Sinks
- Decision Support Tools for Analysis and Visualization
- Management Support Tools to Expand Data and Model Warehouses
- Support for Field Validation
- Education and Outreach





# Advantages of a National Carbon Cyberinfrastructure

- De-centralization of metadata and data
  - Minimize replication of data that can be served in a web service environment
  - National layers can be provided by large data warehouses (e.g., EROS, GeographyNetwork, Census Bureau, NatCarb)
- Local control over data layers (maintain, enhance, add)
- Data requests and structures driven by XML
- Server resources are split among different computers
- Portal requests data in a multithreaded fashion
- Custom Analysis tools can operate on multiple datasets
- Portal is interoperable with different databases in different formats
- Tools to manage system and enhance data
- Synergy among GIS/IT personnel across partnerships

# Selected Recent NatCarb Products

- NatCarb Explorer
  - Focus on the general user
  - Provide higher quality images
- Improved Data Access & Visualization Tools
  - Source Characterization
  - Brine Geochemistry
- Improved Data Management Tools
  - Flexible Online Data Loading

# NatCarb

NatCarb Home Page - Mozilla Firefox

File Edit View Go Bookmarks Tools Help



**NatCarb**  
a national look at carbon sequestration  
NETL

**ATLAS START**

- CLIMATE CHANGE
- SEQUESTRATION
- PARTNERSHIPS
- SOURCES
- SINKS
- INTERACTIVE MAP

**National Carbon Explorer**

The process of sequestering carbon dioxide (CO<sub>2</sub>) involves identifying **sources** that produce CO<sub>2</sub> and **sinks** where the CO<sub>2</sub> can be stored. These web pages present interactive maps and background information on the process of storing CO<sub>2</sub>. This Atlas is created by the NatCarb project and sponsored by the U.S. Department of Energy's National Energy Technology Laboratory.

It left to explore climate change, common sources of greenhouse gasses, and the many ways those gases can be removed from the atmosphere and stored. The [complete atlas](#) is available from the [National Energy Technology Laboratory](#)

Also available online is additional information on the [NatCarb Project](#), whose goal is to create a national view of carbon sequestration by linking regionally managed databases. The main site includes the original [NatCarb Interactive Map](#), a more robust version of the maps presented in the new Atlas linked at left.

This server is run by the [Kansas Geological Survey](#) for NatCarb, a project funded by the U.S. Dept. of Energy's [National Energy Technology Laboratory](#).  
This page Updated March 29, 2007.  
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Comments to [webadmin@kgs.ku.edu](mailto:webadmin@kgs.ku.edu)  
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<http://www.natcarb.org>

# NatCarb Explorer - Sources

NatCarb Home Page - Sources - Mozilla Firefox

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**Sources**

There are two types of CO<sub>2</sub> emission sources: stationary sources and non-stationary sources. Stationary source emissions come from a particular, identifiable, localized source, such as a power plant. CO<sub>2</sub> from stationary sources can be separated from stack gas emissions and subsequently transported to a geologic sequestration injection site for subsurface storage. The "North American CO<sub>2</sub> Sources" map displays the location and relative magnitude of the variety of CO<sub>2</sub> stationary sources. || [View Interactive Map of All Sources](#) || [View Static Map](#)

Non-stationary source emissions include CO<sub>2</sub> emissions from the transportation sector. The evolving terrestrial sequestration technologies are one way to address these emissions.

According to the EPA, in 2004, total U.S. GHG emissions were estimated at 7,074.4 million metric tons (7,798 million tons) CO<sub>2</sub> equivalent. This estimate included CO<sub>2</sub> emissions as well as other GHGs such as methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), and hydrofluorocarbons (HFCs).

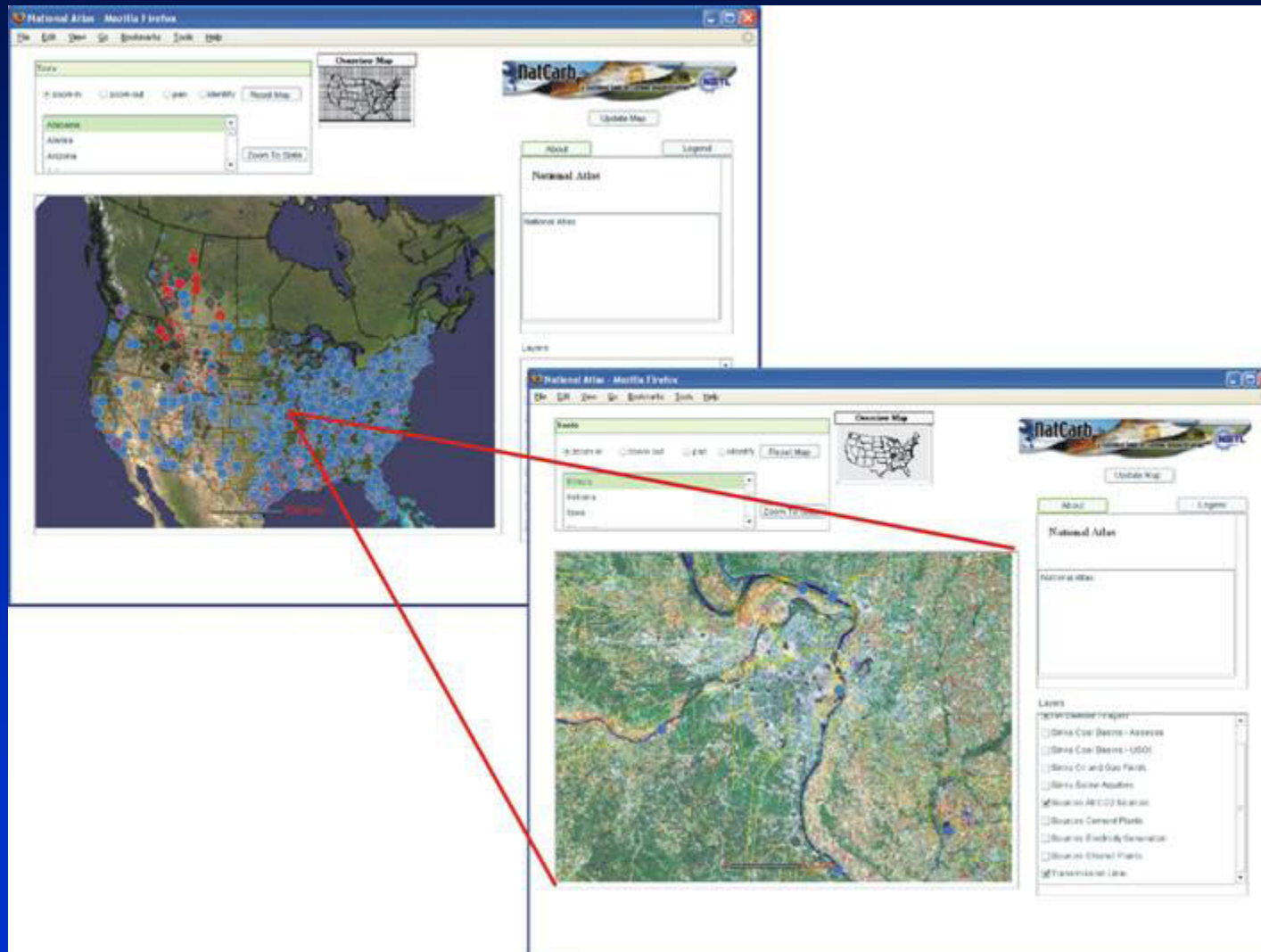
**Percentage CO<sub>2</sub> Stationary Source Emissions by Category**

Category	Percentage
Electricity Generation	86%
Petroleum and Natural Gas Processing	4.6%
Industrial	2.2%
Cement	2.6%
Fertilizer	0.4%
Agriculture Processing	0.2%
Refineries/Chemical	0.2%

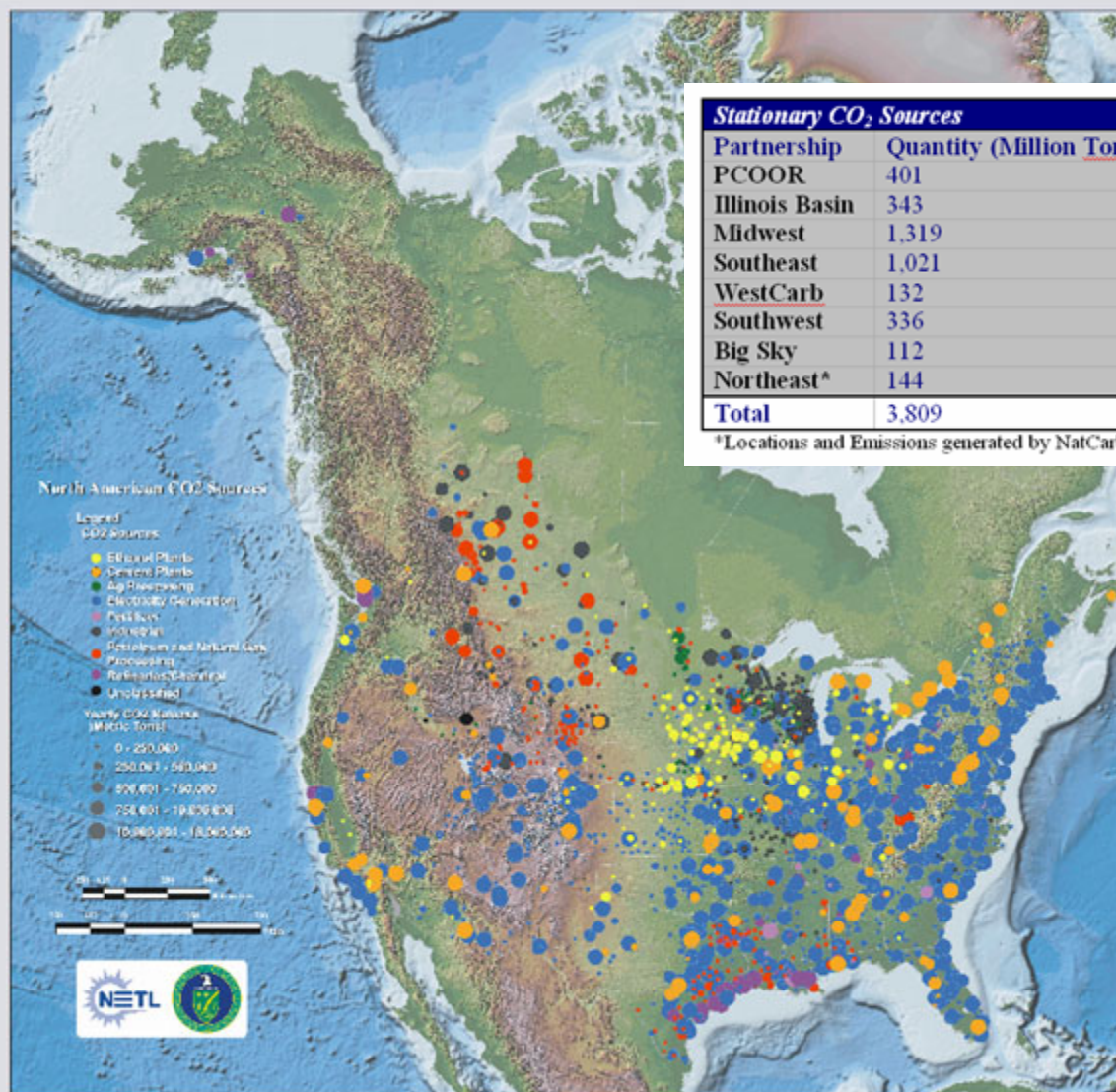
The "Percentage CO<sub>2</sub> Stationary Source Emissions by Category" pie chart contains values, gathered by the RCSPs and NATCARB (illustrated on the "North American CO<sub>2</sub> Sources" map), showing that CO<sub>2</sub> stationary source emissions result largely from energy use and industrial processes. While not all potential GHG sources have been examined, NETL's RCSPs have documented the location of more than 4,365 stationary sources with total emissions of 3,809 million metric tons of CO<sub>2</sub>. The "CO<sub>2</sub>



# NatCarb Explorer



# CO<sub>2</sub> Sources - High Quality Image



## Stationary CO<sub>2</sub> Sources

Partnership	Quantity (Million Tonnes)	Number of Facilities
PCOOR	401	1,037
Illinois Basin	343	212
Midwest	1,319	496
Southeast	1,021	981
WestCarb	132	62
Southwest	336	432
Big Sky	112	158
Northeast*	144	987
<b>Total</b>	<b>3,809</b>	<b>4,365</b>

\*Locations and Emissions generated by NatCarb

# NatCarb Explorer - Sinks

NatCarb Home Page - Sinks - Mozilla Firefox

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**NatCarb**  
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SEQUESTRATION  
PARTNERSHIPS  
SOURCES  
**SINKS**  
INTERACTIVE MAP

### Sinks

A carbon dioxide (CO<sub>2</sub>) sink is a location or process that will store CO<sub>2</sub> from the atmosphere for hundreds to thousands of years. Terrestrial sinks include CO<sub>2</sub> uptake by plants and soils. Geologic sinks include formations with layers of porous rock deep underground that are "capped" by a layer of non-porous rock above them. Research efforts for geologic sinks are concentrated on depleted oil and gas formations, deep unmineable coal basins, and deep saline formations.

**Terrestrial sequestration** uses agricultural methods to increase the amount of carbon stored. By creating greenbelts, increased tree plantings, or altering agricultural production practices, increasing mounts of carbon can be removed, at least temporarily, from the atmosphere. [More...](#) [View Map.](#)

**Oil and Gas Reservoirs** are great locations for storing CO<sub>2</sub>. Once the oil and gas has been removed from a field, the space created can be used for the long-term storage of CO<sub>2</sub>. In addition, in some fields the CO<sub>2</sub> can help to mobilize remaining oil, thus increasing production. [More...](#) [Interactive Map](#) [Static Map.](#)

**Unmineable Coal Seams**, located in many parts of North America, are great possibilities for long-term geological sequestration of CO<sub>2</sub>. In addition to simply providing a porous mineral to hold the carbon dioxide, the gas may increase methane production from the basins. [More...](#) [Interactive Map](#) [Static Map.](#)

**Deep Saline Formations** are layers of porous rock that are saturated with brine. They are much more commonplace than coal seams or oil and gas bearing rock, and represent an enormous potential for CO<sub>2</sub> storage capacity. However, much less is known about saline formations than is known about crude oil reservoirs and coal seams and there is a greater amount of uncertainty as to their amenability to CO<sub>2</sub> storage. [More...](#) [Interactive Map](#) [Static Map.](#)

### Future Geologic Sequestration Options

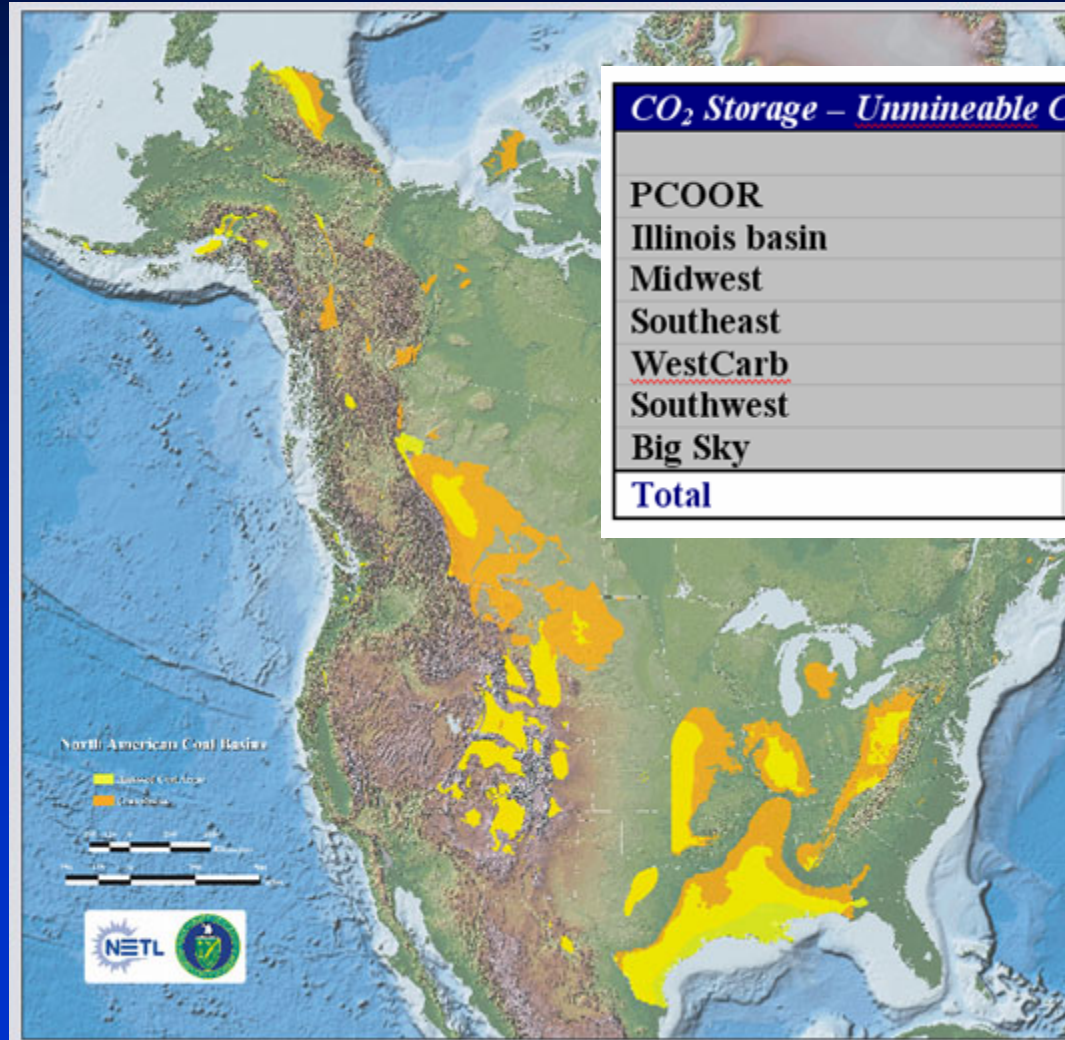
Other possible geologic sequestration options include basalts and shale formations.

**Basalt Formations**--Basalt formations are geologic formations of solidified lava. Basalt formations have a unique chemical makeup that could potentially convert all of the injected CO<sub>2</sub> to a solid mineral form, thus isolating it from the atmosphere permanently. Research is focused on enhancing and utilizing the mineralization reactions and increasing CO<sub>2</sub> flow within a basalt formation.

**Organic Rich Shales**--Shale, the most common type of sedimentary rock, is characterized by thin horizontal layers of rock with very low permeability in the vertical direction. Many shales contain 1-2



# Sinks - High Quality Image



**CO<sub>2</sub> Storage – *Unmineable Coal (Giga Tonnes)***

	Low	High
PCOOR	8	8
Illinois basin	2.3	3.3
Midwest	0.9	0.9
Southeast	57.4	82.1
WestCarb	0	0
Southwest	0.85	2.3
Big Sky	0	0
<b>Total</b>	<b>69.5</b>	<b>96.6</b>



# NatCarb Interactive Map

NatCarb Home Page - Interactive Map - Mozilla Firefox

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ATLAS START  
CLIMATE CHANGE  
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SINKS  
**INTERACTIVE MAP**

**Mapping CO<sub>2</sub> Sources and Sinks**

In addition to contributing national maps to the [Carbon Sequestration Atlas of the United States and Canada](#), the NatCarb project has created several interactive mapping systems.

For exploring North America's CO<sub>2</sub> sources and sequestration opportunities, the [online atlas pages](#) have online mapping systems focussed on specific topics. These maps, on topics such as

- [Stationary Emission Sources](#),
- [Electric Power Utilities](#),
- [Oil and Gas Fields](#),
- [Deep Saline Formations](#),
- and many other topics

are easy to use while being powerful tools to explore specific resources.

**Zoom in or out, or jump to a specific state**

**Click on points to learn more**

**Add other layers to customize your view**

Experienced users may wish to access the original [NatCarb Interactive Map](#). This system brings together all parts of the NatCarb data structure, and leverages data acquisition and processing by all the Regional Carbon Sequestration Partnerships. The full mapping system is a more sophisticated tool, and has options and choices for detailed exploration of the issues surrounding carbon sequestration in North America.

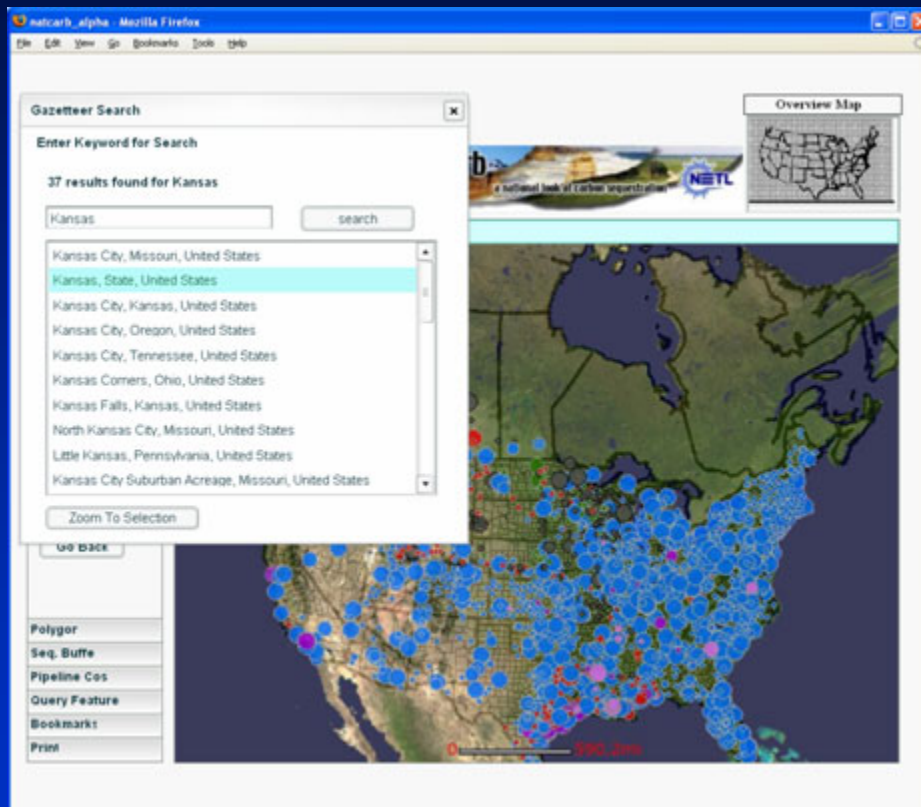
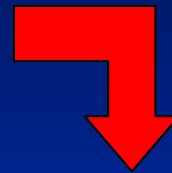
This server is run by the [Kansas Geological Survey](#) for NatCarb, a project funded by the U.S. Dept. of Energy's [National Energy Technology Laboratory](#).  
This page Updated April 19, 2007.  
The URL for this page is [http://www.netcarb.org/atlas/ins\\_map.html](http://www.netcarb.org/atlas/ins_map.html)

# Electric Generation CO<sub>2</sub> Emissions

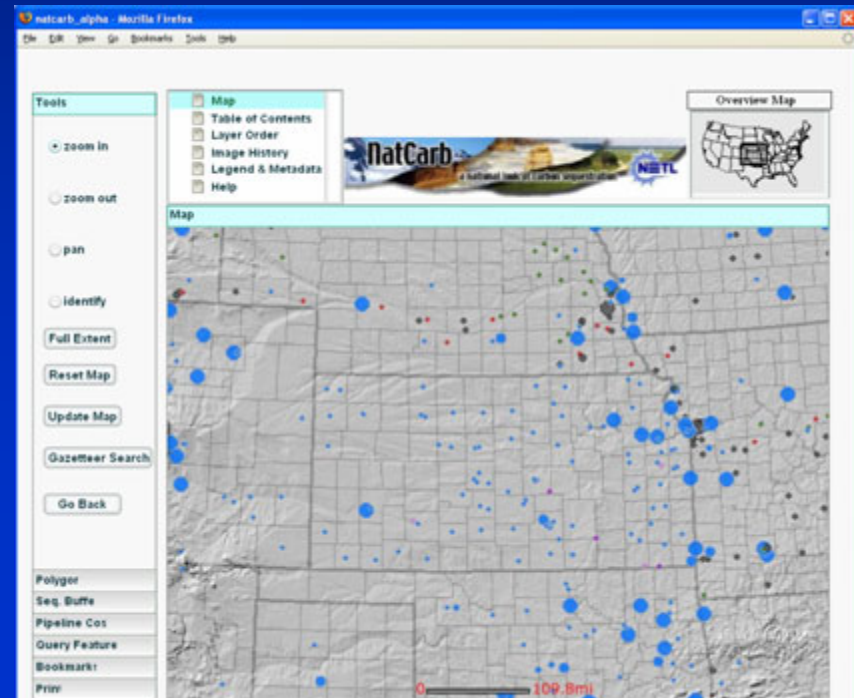


# Display and Analysis

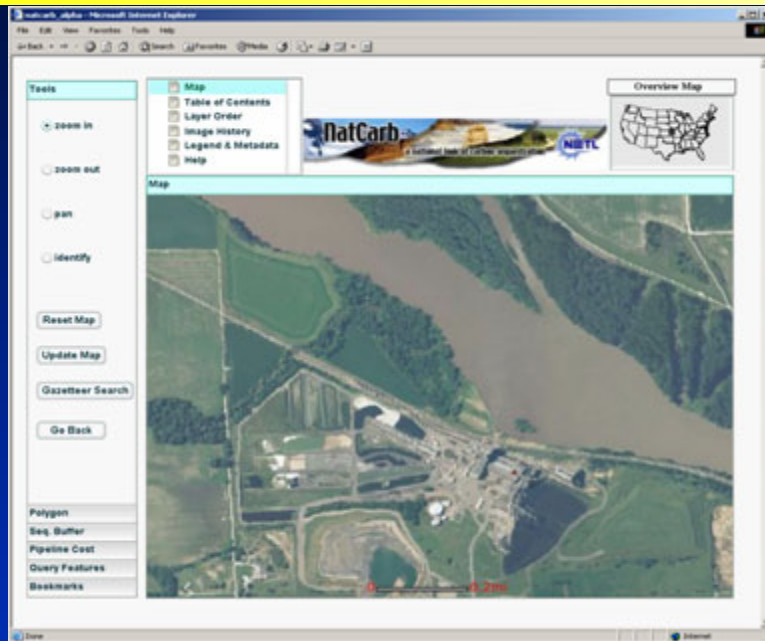
From  
National  
View



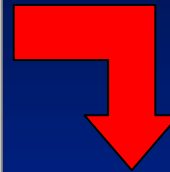
To  
Regional  
View



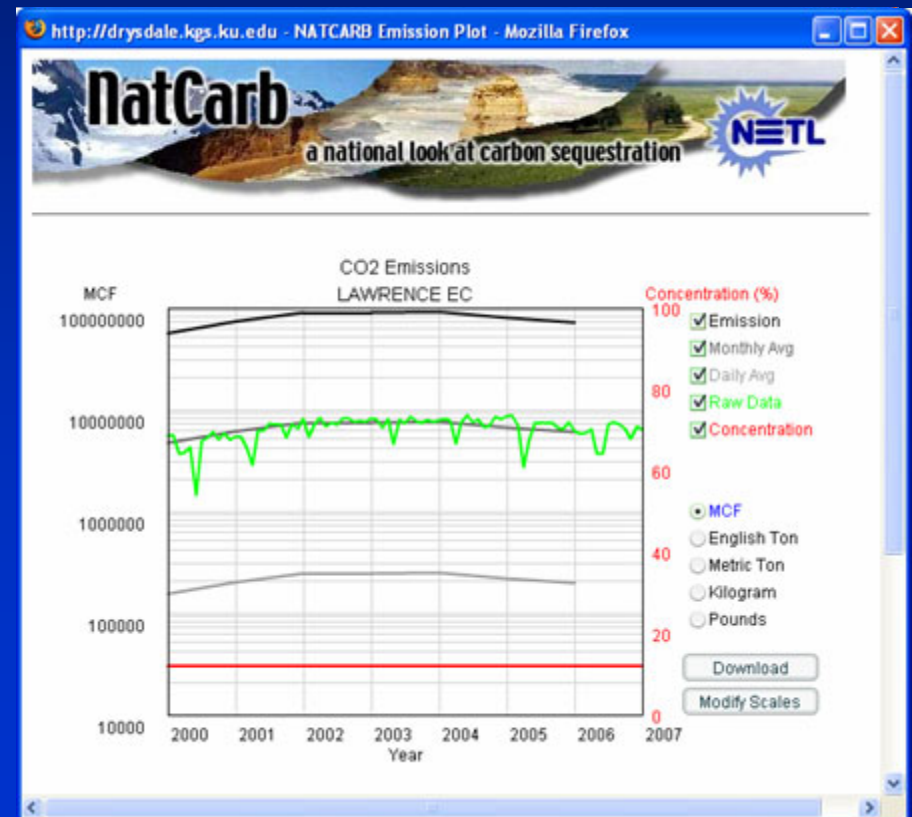
# Display and Analysis



From  
Local  
View

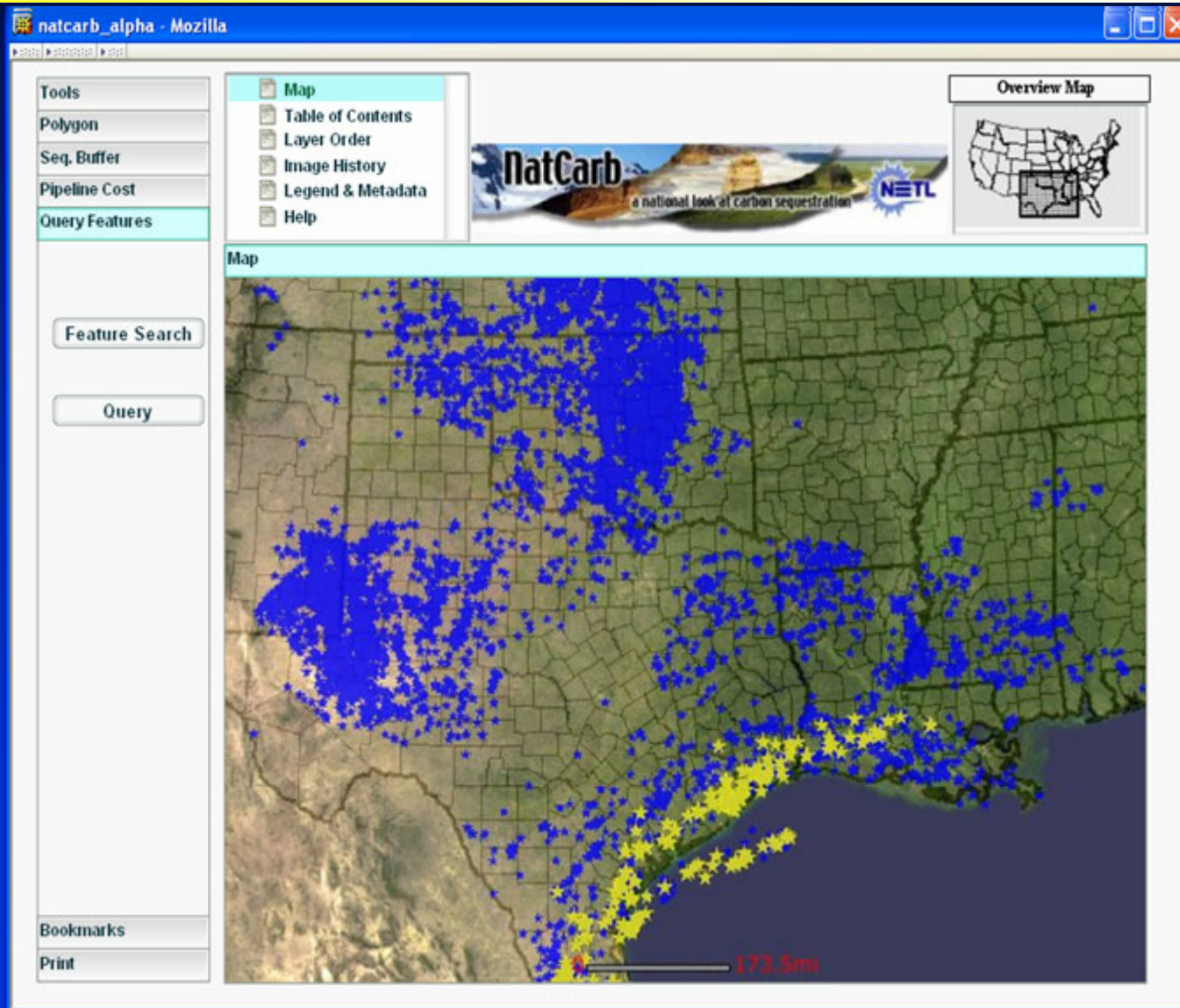


To Analysis

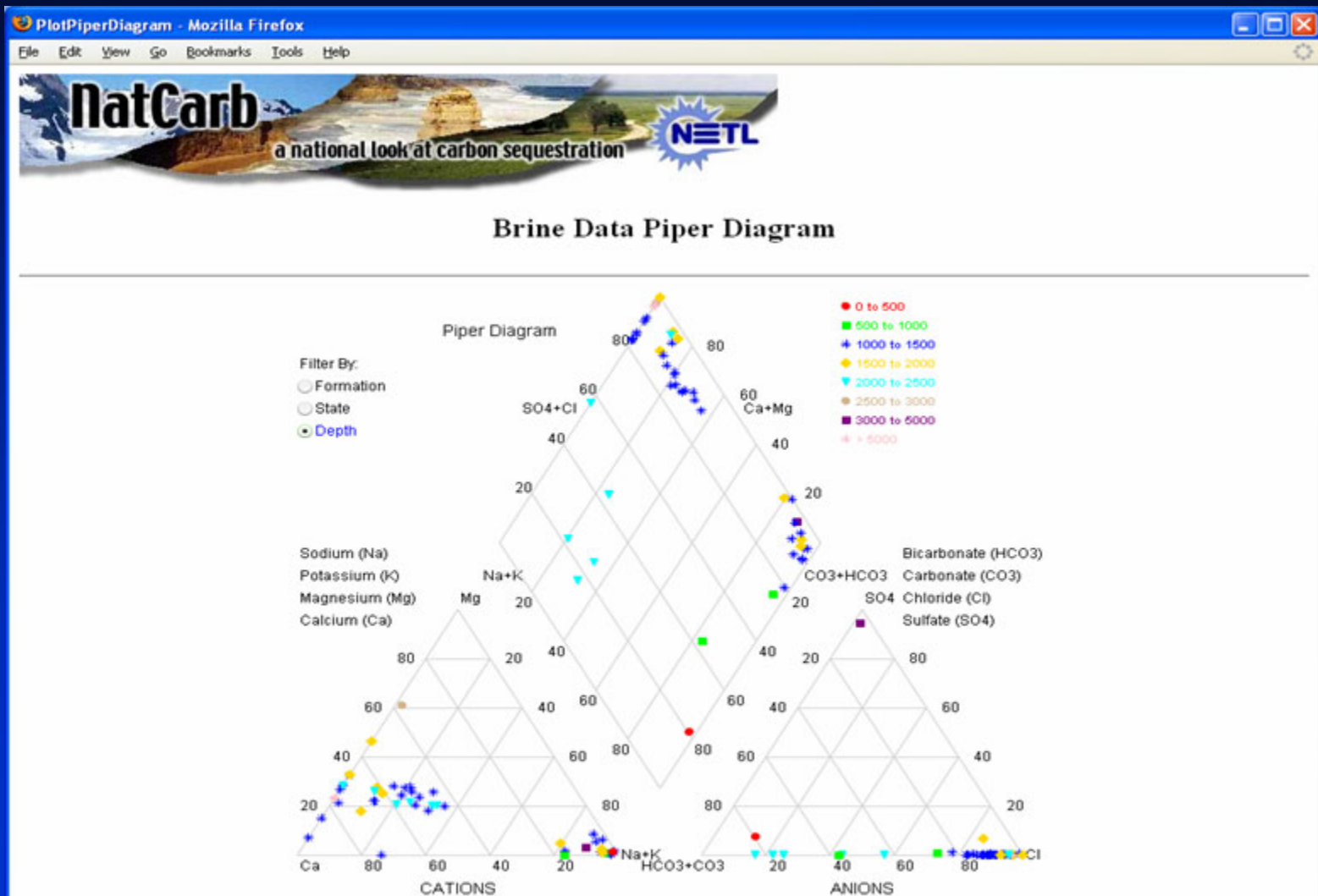




# NatCarb Brine Databases

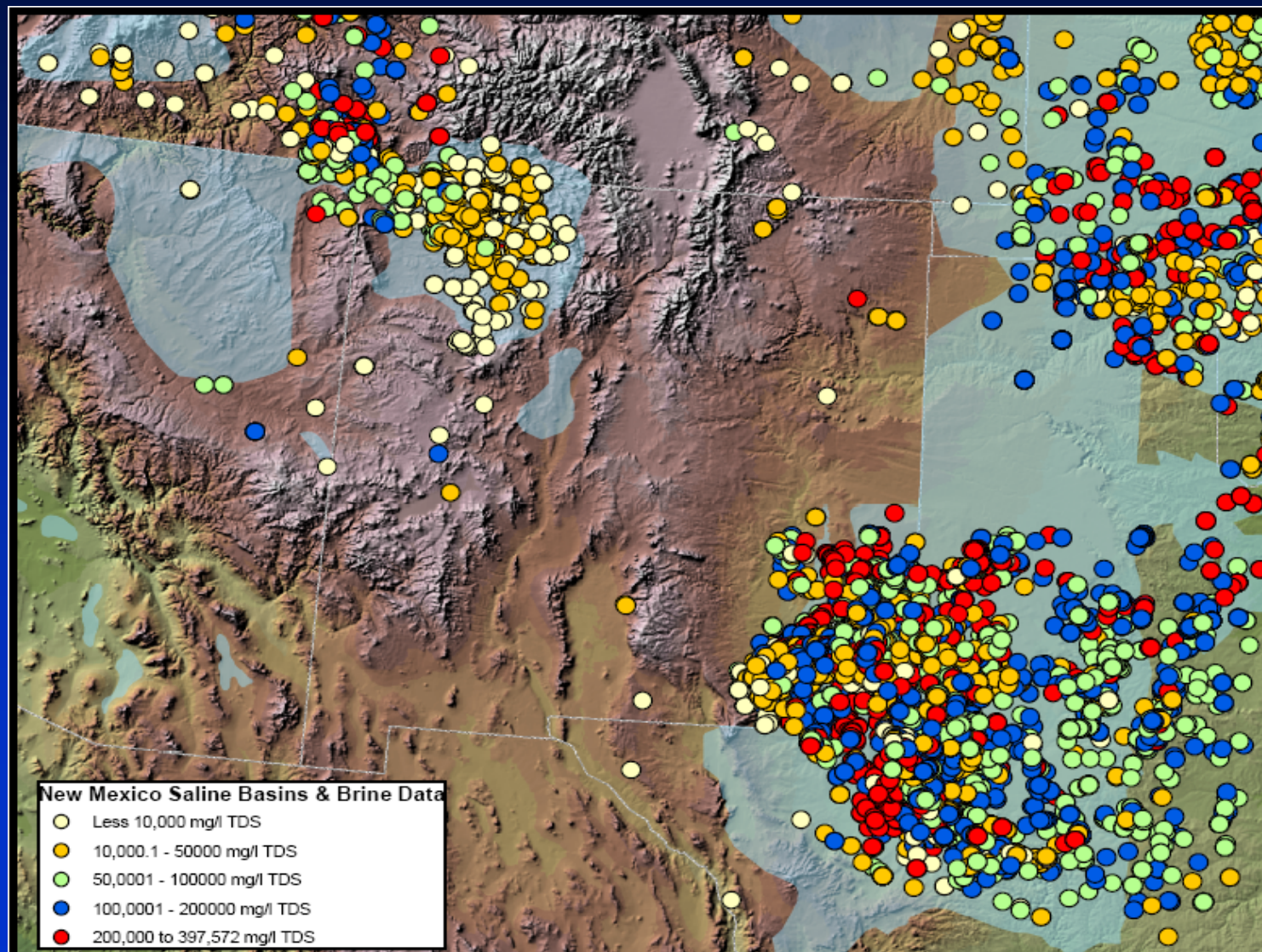


# NatCarb Brine Databases





# Custom Maps



# Distributed Data Loading

Upload ASCII Delimited Data File Action - Mozilla

## Upload ASCII Delimited Data File Action

---


**File successfully moved!**  
Database Save Error:

### User Information

User name: Tim Carr  
User Email: tcarr@kgs.ku.edu


### ASCII Delimited File Information

Original File Name: water\_samples\_nm\_co.csv  
New File Name: (VORTEX DIRECTORY)/1034568820.csv  
Proprietary: No



**Save to KGS Database**

Please Select the icon to the left to continue the process of loading the data from the data file you just uploaded into the Kansas Geological Survey Database. The web page that will be displayed will help you map the columns in your data file to columns in the KGS database table. The web page will try to automatically map some of the columns by the labels that were provide in the data file.



**Return to Upload Page**

Return to the Upload Digital LAS Files Web Page.



# Distributed Data Loading

Show Data File First Line - Mozilla

K	Potassium		
Na	Sodium	mg/l	5200
Ca	Calcium	mg/l	
Mg	Magnesium	mg/l	
Ba	IGNORE COLUMN	mg/l	
Mn	IGNORE COLUMN	mg/l	
Sr	Strontium	mg/l	2
Fe	Iron	mg/l	
SO	IGNORE COLUMN	mg/l	
Cl	Chloride	mg/l	6035
(CO3)-2	IGNORE COLUMN	mg/l	1.45
HCO3	Barcarbonate	mg/l	
OH	IGNORE COLUMN	mg/l	
H2S	Hydrogen Sulfide	mg/l	
CO2	IGNORE COLUMN	mg/l	
O	IGNORE COLUMN	mg/l	
I	Iodine	mg/l	1.458
d18 O	IGNORE COLUMN	0/00	-30.61
dD	IGNORE COLUMN	0/00	-127.6
87/86 Sr	IGNORE COLUMN		0.708197
129I/I	IGNORE COLUMN	1.00E-14	790
I age	IGNORE COLUMN	MA	15
36Cl/Cl	IGNORE COLUMN	1.00E-14	N.D.
Cl age	IGNORE COLUMN	MA	N.D.
Source	Data Source		Riese et al. 2005

Save to KGS Database

# Distributed Data Loading

Map Data File To DB Columns - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

ID: 1036872175 Data Type: brine Filename: 1036872175.csv Data Starts in Row: 3

Data File Column (Row 1)	Select Button to Find DB Column	Maps to Database Column	Modify Data Value By	Select to DB Units	Maps to Database Units	Data File Units (Row 2)	Data File Data (Row 3)
KGS lab	Select Column	IGNORE COLUMN		Units		number	060001
Lab project	Select Column	IGNORE COLUMN		Units		number	CBM-005
Study project	Select Column	IGNORE COLUMN		Units		number	FSMP-001
Site	Select Column	IGNORE COLUMN		Units		name	Keller 10-4
CO	Select Column	County		Units	mol		Bourbon
Operator	Select Column	Operator		Units			Fort Scott
API	Select Column	API-Number		Units			15-011-2311
Latitude	Select Column	Latitude		Units	deg		37.71251
Longitude	Select Column	Longitude		Units	deg		-94.9805
Sample	Select Column	IGNORE COLUMN		Units		locatio	E2 SE NE Se
Sample	Select Column	Sample Date		Units		date	12/14/2005
Sp.C.	Select Column	Specific Conductivity		Units	umhos/cm	uS/cm	30640
TDS	Select Column	Total Dissolved Solids		Units	mol	mg/L	18420
pH	Select Column						
SiO2	Select Column						
Ca	Select Column						
Mg	Select Column						
Na	Select Column						
K	Select Column						
Sr	Select Column						
HCO3	Select Column						
SO4	Select Column	Sulfate		Units	mol	mg/L	24.2
Cl	Select Column	Chloride		Units	mol	mg/L	10730
Br	Select Column	Bromine		Units	mol	mg/L	35.0
I	Select Column	Iodine		Units	mol	mg/L	0.89
B	Select Column	IGNORE COLUMN		Units		mg/L	1.761

Please restrict the new column to a measured data that is not already defined.

Column: SiO2

Mnemonic: SiO2 Units: mg/L

☒ Text ☐ Numeric Size: 20

Save Column Name Close

Save

# National Carbon Cyberinfrastructure Summary

- A **National Carbon Cyberinfrastructure** is a Significant Component of National Carbon Sequestration Efforts
- Provides Improved Access to Data and Models, Better Integration, More Effective Science and Engineering, and Enhanced Decision-Making
- **Distributed National Knowledge Base** Permits “Loose Coupling” of Elements of Carbon Science and Decision Support
- A Carbon Cyberinfrastructure:
  - Brings Society Together with Solutions
  - Provides Model to Manage System, Display Data, Integrate Data with Models and Manage Results
- Provides a Method to Bring the Expertise and the Data Together



# Future Short-Term NatCarb Goals

- **Improve Access for General Public**
  - **Improve Summary Layers**
  - **Simplify Navigation**
- **Improve Quality and Coverage of National Atlas**
  - **Overlap Areas**
  - **Increase in Source and Sink Data**
- **Improve Integration**
- **Enhance Distributed and National Databases**
- **Improve performance and stability**
- **Improve National Coverage**
  - **Workshop with Geologic Outreach and GIS Groups**
  - **Work with Entities Outside Partnerships**
- **Assist Efforts Outside North America**







The great expectations held for DDT have been realised. During 1946, exhaustive scientific studies have shown that, when properly used, DDTs a host of destructive pests, and is a benefactor of all humanity.

Pennsalt produces DDT and its products in all standard forms and is now one of the country's largest producers of this amazing insecticide. Today, everyone can enjoy added comfort, health and safety through the insect killing power of Pennalt DDT products...and DDT is only one of many chemical products which benefit industry, farm and home.

KnoxOut for the home--helps to make healthier, more comfortable homes...protects your family from dangerous insect pests. Use KnoxOut DDT powders and sprays as directed...then watch the bugs 'bite the dust'.

KnoxOut for Dairies---Up to 20% more milk...more butter...more cheese...tests prove greater milk production when dairy cows are protected from the annoyance of many insects with DDT insecticides like KnoxOut Stock and Barn spray

**"DDT is good for me-e-e!"**

The great expectations held for DDT have been realized. During 1946, exhaustive scientific tests have shown that, when properly used, DDT kills a host of destructive insect pests, and is a benefactor of all humanity.

Pennsalt produces DDT and its products in all standard forms and is now one of the country's largest producers of this amazing insecticide. Today, everyone can enjoy added comfort, health and safety through the insect-killing powers of Pennsalt DDT products . . . and DDT is only one of Pennsalt's many chemical products which benefit industry, farm and home.

**GOOD FOR FRUITS**—Bigger apples, juicier fruits that are free from unsightly worms . . . all benefits resulting from DDT dusts and sprays.

**GOOD FOR STEERS**—Beef grows healthier now . . . for it's a scientific fact that—compared to untreated cattle—beef-steers gain up to 50 pounds extra when protected from horn flies and many other pests with DDT insecticides.

**KNOX OUT FOR THE HOME**—helps to make healthier, more comfortable homes . . . protects your family from dangerous insect pests. Use Knox-Out DDT Powders and Sprays as directed . . . then watch the bugs "bite the dust"!

**KNOX OUT FOR DAIRIES**—Up to 20% more milk . . . more butter . . . more cheese . . . tests prove greater milk production when dairy cows are protected from the annoyance of many insects with DDT insecticides like Knox-Out Stock and Barn Spray.

**GOOD FOR ROW CROPS**—25 more barrels of potatoes per acre . . . actual DDT tests have shown crop increases like this! DDT dusts and sprays help truck farmers gain these gains along to you.

**KNOX OUT FOR INDUSTRY**—Food processing plants, laundries, dry cleaning plants, hotels . . . dozens of industries gain effective bug control, more pleasant work conditions with Pennsalt DDT products.

**KILLING SALT**  
CHEMICALS  
87 Years' Service to Industry • Farm • Home

She longed for a Star Trek-type doctor with a state-of-the-art diagnostic tool. The doctor, with a few computer bleeps, would locate the exact cause of her newly discovered and doctor-baffling skin lesions and assign a painless treatment with no side effects.

[http://www.whale.to/vaccines/ddt\\_spraying.html](http://www.whale.to/vaccines/ddt_spraying.html)